Holistic Watershed Approach

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Abstract

The Holistic Watershed Approach provides an all encompassing study of an entire watershed in which all treatment alternatives for polluted coal mine drainage (PCMD) from abandoned mine lands are evaluated and the concern of all interested parties are accommodated. By applying the Holistic Watershed Approach, six major benefits can be accomplished.

First, the approach *establishes* guidelines for a universal monitoring procedure applicable to multi-user needs. In the past, data has been collected by various federal, state, and local agencies, citizen groups, and industry according to their own needs. When the data is shared among the various users, many times parameters needed by the second party are missing.

Second, the Holistic Watershed Approach *delineates* the watershed wide impacts of PCMD from abandoned mine lands sources by providing a snapshot of the entire watershed for a range of flow conditions. Comprehensive sampling of all tributaries and mainstem stream segments throughout a watershed enables a selection of problem areas for treatment.

After the problem areas within a watershed have been identified, the Holistic Watershed Approach *prioritizes* affected stream segments and tributaries by comparing acid and alkaline loading based on flow and water chemistry data. The affected stream segments and tributaries near the headwaters receive a higher priority because the water from these affected areas will have detrimental affect on the entire watershed.

Once a high priority problem area has been determined, water chemistry and flow data of the PCMD source water and the receiving stream are collectd and analyzed. The Holistic Watershed Approach then *designates* the appropriate pollution treatment alternative based on stream and PCMD source criteria. Some treatment examples are: wetlands, limestone channels, and in-stream limestone treatment. In addition to PCMD, the Holistic Watershed Approach can be used to determine the affects of other pollutant sources within a watershed.

The approach allows uniform *documentation* of biological, chemical, and physical conditions in a watershed. The documentation provides criteria for comparison of water quality before treatment to water quality after treatment. Coordinated efforts of federal, state, and local government agencies; and citizen groups allows large scale biological, chemical, and physical

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surveys to be conducted within a watershed. A watershed survey could be too large of a scope for an individual agency or group, but can be accomplished through such coordinated efforts. Finally, the Holistic Watershed Approach *relates* to the public by providing highly visible, measurable environmental indicators of stream conditions based on aquatic organisms and stream usage. Public interest is stimulated by easily recognizable benefits.

By applying the Holistic Watershed Approach through cooperative efforts of the West Virginia Division of Environmental Protection Office of Abandoned Mine Land & Reclamation, other government agencies, industry, and the public, the natural splendor of the streams and ecosystems of the state can be restored.

West Virginia Division of Environmental Protection
Office of Abandoned Mine Lands & Reclamation
Stream Restoration Group's

HOLISITIC WATERSHED APPROACH PROTOCOL

I. Define the *study area*.

- Select mainstem stream and determine watershed boundary.

II. Establish *comprehensive monitoring network* within the *study area*.

- Select and number stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations and at extensive locations throughout the mainstem tributary stream reach.
    - Establish project name and nomenclature.
    - Number all stream sampling stations in ascending order, beginning with the most downstream station.

III. Obtain coordinates and map *comprehensive monitoring network* for Geographical Information System (GIS) input.

- Process Global Positioning System (GPS) Data
    - Collect sampling station positions using Global Positioning System data capture equipment.
    - Update Stream Restoration Group Project Log.
        - Record project name, date of Global Positioning System coordinate collection.
    - Correct Global Positioning System data.
    - Enter Coordinates into Q&A database.
    - Update Stream Restoration Group Project Coordinates Log
        - Record project name and nomenclature; sample number, latitude, and longitude; and horizontal precision.
    - Provide Q&A database to TAGIS for Geographical Information System (GIS) analysis.
- Generate project map of all sampling stations.

IV. Implement sampling sweeps of the *comprehensive monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
    - Prepare chain of custody (COC) form for laboratory.
        - Chain of Custody form includes project nomenclature and name, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH, and specific conductivity; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.
        - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
    - Prepare sampling stations for water sample collection.
        - Stake sampling stations as close to collection point as possible.
            - Label stake with sampling station number.
    - Perform water sample collection.
        - Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
            - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
            - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
            - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
    - Perform field measurements.
        - Obtain insitu values of water quality measurements at all sampling stations.
            - Measure temperature, pH, and specific conductivity.
        - Obtain stream flow.
            - Measure uniform width segments of the total water cross section utilizing a tagline.
                - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
            - Record average width of segments (tenths of feet).
                - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
            - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.

- Record water depth (tenths of feet).
- Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
- Record velocity (feet per second)
- Calculate and record total flow (cubic feet per second).
    - Σ (average width x depth x velocity) = flow

- Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
    - Record field notes.
    - Sketch and photograph sampling station.
- Update Stream Restoration Group Project Log.
    - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, and downstream flow measurement.

- Conduct *Biological and Physical Study* one time between April and November.
    - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
        - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of bioassessment.
    - Perform fish survey at selective stream sampling stations only.

V. Review all data collected. (If watershed is large continue. If watershed is small skip to VIII.)

- Analyze changes in tributary and mainstem stream segments and compare tributaries.
    - Represent *Water Quality Study* data graphically.
    - Compare *Biological and Physical Study* data.

VI. Establish *streamlined monitoring network* within the *comprehensive monitoring network*.

- Select and number stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations only.
    - Stream sampling station numbers remain the same as in *comprehensive monitoring network.*

VII. Implement sampling sweeps of *streamlined monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
    - Prepare chain of custody (COC) form for laboratory.
        - Chain of Custody form includes project nomenclature and name, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH and specific conductivity; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.
        - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
    - Perform water sample collection.
        - Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
            - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
            - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
            - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
    - Perform field measurements.
        - Obtain insitu values of water temperature, pH, and specific conductivity.
        - Obtain stream flow.
            - Measure uniform width segments of the total water cross section utilizing a tagline.
                - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
            - Record average width of segments (tenths of feet).
                - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
            - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
            - Record water depth (tenths of feet).
            - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.

        - Record velocity (feet per second)
        - Calculate and record total flow (cubic feet per second).
            - Σ (average width x depth x velocity) = flow
    - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
        - Record field notes.
        - Sketch and photograph sampling station.
    - Update Stream Restoration Group Project Log.
        - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, and downstream flow measurement.

VIII. Review all data collected.

- Analyze changes in tributary and mainstem stream segments and compare tributaries.
    - Represent *Water Quality Study* data graphically.
    - Compare *Biological and Physical Study* data.
    - Prioritize mainstem tributaries according to degree of impairment.

IX. Define *focus study area*.

- Select impaired tributary within *comprehensive monitoring network* and determine watershed boundary.

X. Establish *focus area monitoring network* within the *focus study area*.

- Locate polluted coal mine drainage source sampling stations within impaired tributary watershed.
    - Research existing data.
        - Search historical maps, reports, and data.
        - Communicate with local citizen groups or individuals.
        - Communicate with State, Federal, Local agencies.
        - Communicate with local Private Industry.
        - Review Abandoned Mine Lands Inventory, new project priority list, and OSM51/ Environmental Assessments.
            - Communicate with Abandoned Mine Lands North/South Planner to determine water quality projects.
    - Receive notification from Abandoned Mine Lands Realty Administrator that Exploratory Rights of Entry have been obtained at Abandoned Mine Lands water quality projects.
    - Field review entire impaired tributary watershed.
        - Field review Abandoned Mine Lands water quality projects within impaired tributary watershed with Abandoned Mine Lands North/South Planner.

- Establish Project Point of Contact (PPOC).
- Establish project name and nomenclature.
- Establish project boundaries.
- Establish source sampling stations.
    - Number source sampling stations within each project beginning with 100 and incrementing by hundreds to allow numbering space for additional stations which may be encountered.
- Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
    - Record field notes.
    - Sketch and photograph project area.

- Field review remainder of impaired tributary watershed to locate additional polluted coal mine drainage sources which are not associated with Abandoned Mine Lands water quality projects.
    - Establish Project Point of Contact (PPOC).
    - Establish project name and nomenclature.
    - Establish project boundaries.
    - Establish source sampling stations.
        - Number source sampling stations within each project beginning with 100 and incrementing by hundreds to allow numbering space for additional stations which may be encountered.
    - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
        - Record field notes.
        - Sketch and photograph project area.
    - Report project to Abandoned Mine Lands North/South Planner.

- Select and number stream sampling stations throughout impaired tributary watershed.
    - Select impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage influx.
    - Select receiving stream sampling stations upstream and downstream of the confluence with the impaired tributary.
    - Number all stream sampling stations in ascending order, beginning with the most downstream station.
- Add projects to Stream Restoration Group Water Quality Assessment Index (WQAI).
    - Include project name and nomenclature, point of contact, water quality assessment type, number of monitoring points, hydrologic region, watershed, receiving stream, 7.5’ USGS topographic map, purpose of assessment, county, coal seam, priority list date, and exploratory right of entry completion date.

XI. Obtain coordinates and map *focus area monitoring network* for Geographical Information System (GIS) input.

- Process Global Positioning System (GPS) Data:
    - Collect sampling station positions using Global Positioning System data capture equipment.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of Global Positioning System coordinate collection.
    - Correct Global Positioning System data.
    - Enter Coordinates into Q&A database.
    - Update Stream Restoration Group Project Coordinates Log
        - Record project name and nomenclature; sample number, latitude, and longitude; and horizontal precision.
    - Provide Q&A database to TAGIS for Geographical Information System (GIS) analysis.
- Generate project map of all sampling stations.

XII. Implement sampling sweeps of *focus area monitoring network*.

- Conduct *Water Quality Study* sweeps six times spanning a range of hydrologic and climatologic conditions.
    - Obtain project reclamation number.
    - Prepare chain of custody (COC) form for laboratory.
        - Chain of Custody form includes project nomenclature and name, project reclamation number, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH specific conductivity and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, calcium, aluminum, and manganese.
            - Pollution source sampling variables include: flow; field temperature, pH, specific conductivity, and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, ferrous and ferric iron, calcium, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.
        - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
    - Prepare sampling stations for water sample collection.
        - Stake stream and source sampling stations as close to collection point as possible.
            - Label stake with sampling station number.

- Dig collection basin at pollution source origin.

- Perform water sample collection.
  - Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
    - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
  - Collect pollution source water sample at origin. (When several seeps co-mingle, it is necessary to collect a sample of the combined discharge.)
    - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
      - Ferrous and ferric iron analyses are not necessary at source stations when the water is impounded and the origin of the source is not "free flowing" accessible.

- Perform field measurements.
  - Obtain insitu water quality measurements at all sampling stations.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at source sampling stations.
      - Dissolved oxygen measurement is not necessary at source stations when the water is impounded and the origin of the source is not "free flowing" accessible, or the origin is not inseparable from other sources.
  - Obtain stream flow.
    - Measure uniform width segments of the total water cross section utilizing a tagline.
      - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.

- Record average width of segments (tenths of feet).
- Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
- Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
- Record water depth (tenths of feet).
- Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
- Record velocity (feet per second)
- Calculate and record total flow (cubic feet per second).
    - Σ (average width x depth x velocity) = flow

- Obtain source flow. (When several seeps co-mingle, it is necessary to measure the flow of the combined discharge.)
    - Dig exit channel from source collection basin.
        - Channel must be wide enough to accommodate wading staff base.
        - Water in channel must be deep enough to submerge velocity sensor.
    - Measure uniform width segments of the total water cross section utilizing a tagline.
        - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
    - Record average width of segments (tenths of feet).
        - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
    - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
    - Record water depth (tenths of feet).
    - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
    - Record velocity (feet per second)
    - Calculate and record total flow (cubic feet per second).
        - Σ (average width x depth x velocity) = flow

- Complete Acid Mine Drainage Assessment (AMDA) Form.
    - Record field notes.
    - Sketch and photograph sampling station.
- Update Stream Restoration Group Project Log.
    - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, downstream flow measurement.
    - Include project status for source sampling stations.

- Update Stream Restoration Group Water Quality Assessment Index (WQAI).
- Add project reclamation number and monitoring starting date.
- Report any portion of project for which polluted water abatement appears infeasible to the Abandoned Mine Lands Design Administrator.
    - Infeasible polluted water abatement areas include: seeps located at or near the stream edge, and seeps or mine openings discharging extremely small flows, if the seep, mine opening discharge, or receiving stream is inaccessible to earthmoving equipment.
- Cease sampling of any portion of project for which polluted water abatement appears infeasible, unless otherwise instructed by the Abandoned Mine Lands Design Administrator.
- Report any additional polluted coal mine drainage sources found on project sites to Abandoned Mine Lands North/South Planner.

- Conduct *Biological and Physical Study* one time between April and November.
    - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of polluted coal mine drainage project areas.
        - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of bioassessment.

XIII. Review data.

- Analyze *focus area monitoring* network data.
    - Represent *Water Quality Study* data graphically and tabularly.
- Field review *focus area* pollution sources with all Stream Restoration Group members.
    - Review Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form notes and sketches.

XIV. Report findings.

- Prepare preliminary pre-design *Water Quality Study* report of findings and suggestions.
    - Determine extent of impairment polluted coal mine drainage contributes to the *focus area* impaired tributaries.
    - Determine site specific polluted coal mine drainage remediation technology for the sources at each project area.
        - Evaluate chemical suitability of selected polluted coal mine drainage remediation technology.
            - Apply Stream Restoration Group Polluted Coal Mine Drainage Remediation criteria flow chart.

- Reference variables include alkalinity, acidity, dissolved oxygen, total iron, ferrous and ferric iron, and aluminum.
- Evaluate physical suitability of selected polluted coal mine drainage remediation technology.
  - Reference variables include flow and geography.
- Determine instream polluted coal mine drainage remediation technology for stream benefits in addition to, or in lieu of site specific polluted coal mine drainage remediation.
  - Reference variables include acidity and flow.

- Submit pre-design *Water Quality Study* report to Abandoned Mine Lands Chief, Design Administrator, Construction Administrator, Project Engineer, North/South Planner, Stream Restoration Group Supervisor, In-House Design Administrator or Design Consultant, and File.
  - Modify preliminary pre-design *Water Quality Study* report, if necessary.
    - Participate in on-site mapping meeting upon request of Abandoned Mine Lands Project Manager.
    - Participate in on-site pre-issuance meeting upon notification from Abandoned Mine Lands Project Manager.
    - Update Stream Restoration Group Water Quality Assessment Index.
      - Record name of project design consultant upon notification from Abandoned Mine Lands Construction Administrator.
    - Participate in any meetings relative to the project upon request of Abandoned Mine Lands Project Manager.
    - Incorporate on-site findings and suggestions into final *Pre-Design Water Quality Study* report.
      - Study will include:
        - Description of impacted stream length and boundary of impacted area
        - Chemical, physical, and biological water quality data
        - Maps
        - Photographs
        - Suggested polluted coal mine drainage remediation technologies for each source or combined sources and/or stream
- Update Stream Restoration Project Log.
  - Record name and date pre-design *Water Quality Study* report was sent.

XV. Establish *post construction focus area monitoring network* when polluted coal mine drainage remediation is complete in the *focus study area*. (If initial *study area* contains other impaired tributaries which have not been addressed, repeat IX through XIV.)

- Locate constructed polluted coal mine drainage remediation systems within polluted coal mine drainage remediation projects.

- Receive notification of polluted coal mine drainage remediation project construction completion date from Abandoned Mine Lands Construction Administrator.
    - Update Stream Restoration Group Water Quality Assessment Index.
        - Include construction completion date, name of contractor, and construction cost.
- Field review polluted coal mine drainage remediation project site with Abandoned Mine Lands Project Inspector.
    - Obtain project map.
    - Establish project boundaries.
    - Establish untreated and treated source sampling stations.
    - Number untreated and treated source sampling stations.
        - Number untreated source sampling stations as previously designated for pre-design *Water Quality Study*.
        - Number treated source sampling stations in ascending order beginning with the station nearest to the untreated station.
    - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
        - Record field notes.
        - Sketch and photograph project area.
- Select and number stream sampling stations throughout *focus study area*.
    - Select the previously impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage remediation project influx.
    - Select receiving stream sampling stations upstream and downstream of the confluence with the previously impaired tributary.
    - Number all stream sampling stations as previously designated for pre-design *Water Quality Study*.
- Update Stream Restoration Group Water Quality Assessment Index (WQAI).
    - Include water quality assessment type and number of monitoring points.

XVI. Obtain coordinates and map *post construction focus area monitoring network* for Geographical Information System (GIS) input.

- Process Global Positioning System (GPS) Data:
    - Collect positions for any sampling stations added since pre-design *focus area monitoring network* was established using Global Positioning System data capture equipment.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of Global Positioning System coordinate collection.
    - Correct Global Positioning System data.
    - Enter Coordinates into Q&A database.

- Update Stream Restoration Group Project Coordinates Log
    - Record project name and nomenclature; sample number, latitude, and longitude; and horizontal precision.
- Provide Q&A database to TAGIS for Geographical Information System (GIS) analysis.
- Generate project map of all sampling stations.

XVII. Implement sampling sweeps of *post construction focus area monitoring network*.

- Conduct *Water Quality Study* sweeps six times per year during the initial first year period; four times during the second year period; and two times per year during the third and every subsequent year period spanning a range of hydrologic and climatologic conditions.
    - Prepare chain of custody (COC) form for laboratory.
        - Chain of Custody form includes project nomenclature and name, project reclamation number, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH specific conductivity and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, calcium, aluminum, and manganese.
            - Untreated pollution source sampling variables include: flow; field temperature, pH, specific conductivity, and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, ferrous and ferric iron, calcium, aluminum, and manganese.
            - Treated pollution source sampling variables include: flow; field temperature, pH, specific conductivity, Oxygen Reduction Potential, and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, ferrous and ferric iron, calcium, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.
        - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
    - Prepare sampling stations for water sample collection.
        - Stake stream and source sampling stations as close to collection point as possible.
            - Label stake with sampling station number.
        - Dig collection basin at pollution source origin.

- Perform water sample collection.
- Collect stream water sample for laboratory analysis employing “grab” sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
    - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
  - Collect untreated source water sample at origin if possible.
    - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
        - Ferrous and ferric iron analyses are not necessary at source stations when the water is impounded and the origin of the source is not “free flowing” accessible.
  - Collect treated source water sample at polluted coal mine drainage remediation system outflow.
    - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
        - Ferrous and ferric iron analyses are not necessary at polluted coal mine drainage remediation system stations where the water is aerated.
- Perform field measurements.
  - Obtain insitu water quality measurements at all sampling stations.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at untreated source sampling stations.

- Measure temperature, pH, specific conductivity, Oxygen Reduction Potential, and dissolved oxygen at treated source sampling stations.
    - Oxygen Reduction Potential and dissolved oxygen are not necessary at polluted coal mine drainage remediation system stations where the water is aerated.
- Obtain stream flow.
    - Measure uniform width segments of the total water cross section utilizing a tagline.
        - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
    - Record average width of segments (tenths of feet).
        - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
    - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
    - Record water depth (tenths of feet).
    - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
    - Record velocity (feet per second)
    - Calculate and record total flow (cubic feet per second).
        - Σ (average width x depth x velocity) = flow
- Obtain treated source flow at polluted coal mine drainage remediation system outflow.
    - Measure uniform width segments of the total water cross section utilizing a tagline.
        - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
    - Record average width of segments (tenths of feet).
        - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
    - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
    - Record water depth (tenths of feet).
    - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
    - Record velocity (feet per second)
    - Calculate and record total flow (cubic feet per second).
        - Σ (average width x depth x velocity) = flow
- Complete Acid Mine Drainage Assessment (AMDA) Form.
    - Record field notes.
    - Sketch and photograph sampling station.

- Update Stream Restoration Group Project Log.
    - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, downstream flow measurement.
    - Include project status for source sampling stations.
- Update Stream Restoration Group Water Quality Assessment Index (WQAI).
    - Add monitoring starting date.
- Report any anomalies noticed at the project during routine monitoring to the Abandoned Mine Lands Construction Administrator.
- Cease sampling of project if it requires maintenance or modifications unless otherwise instructed by the Abandoned Mine Lands Construction Administrator.
- Resume monitoring of project upon notification from Construction Administrator of project maintenance completion.
    - Notification should include explanation of maintenance and any modification which could affect *focus area monitoring network*.

- Conduct *Biological and Physical Study* one time between April and November, at least one year after completion of project construction.
    - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of polluted coal mine drainage remediation project influx.
        - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of bioassessment.

XVIII. Implement sampling sweeps of the *comprehensive monitoring network* when polluted coal mine drainage remediation is complete throughout initial *study area*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
    - Utilize chain of custody (COC) form prepared for laboratory during initial monitoring of the *comprehensive monitoring network*.
        - Chain of Custody form includes project nomenclature and name, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH, and specific conductivity; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.

- Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.

- Prepare sampling stations for water sample collection.
  - Stake sampling stations as close to collection point as possible.
    - Label stake with sampling station number.
- Perform water sample collection.
  - Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
    - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
  - Obtain insitu values of water quality measurements at all sampling stations.
    - Measure temperature, pH, and specific conductivity.
  - Obtain stream flow.
    - Measure uniform width segments of the total water cross section utilizing a tagline.
      - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
    - Record average width of segments (tenths of feet).
      - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
    - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
    - Record water depth (tenths of feet).
    - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
    - Record velocity (feet per second)
    - Calculate and record total flow (cubic feet per second).
      - Σ (average width x depth x velocity) = flow
- Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
  - Record field notes.
  - Sketch and photograph sampling station.
- Update Stream Restoration Group Project Log.

- Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, and downstream flow measurement.

- Conduct *Biological and Physical Study* one time between April and November.
  - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
    - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
  - Update Stream Restoration Group Project Log.
    - Record project name and date of bioassessment.
  - Perform fish survey at selective stream sampling stations only.

XIX. Review data.

- Analyze changes in stream water quality.
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- Analyze effectiveness and efficiency of constructed polluted coal mine drainage remediation systems.
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  -

XX. Report findings.

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- Submit final *post construction Water Quality Study* report to Abandoned Mine Lands Chief, Design Administrator, Construction Administrator, Project Engineer, Stream Restoration Group Supervisor, In-House Design Administrator, and File.
  - Determine the effect of constructed polluted mine drainage remediation systems on the polluted mine drainage sources, *focus area monitoring networks*, and *comprehensive monitoring network.*
  - Study will include:
    - Introduction and History of Project
    - Drainage Area
    - Sampling protocol
    - Water Quality Data
    - Mapping
    - Personnel Involved
    - Photos
    - Design Construction Map
    - Materials used for Construction
    - Construction Cost
    - Time Frame
    - Water Quality Improvements:

- Acid Reduction through Project
- Metal Reduction through Project
- Reduction in Acid Load to Receiving Stream
- Biological Assessment, (Upstream verses Downstream)

- Graphs and Charts

ARC View Pictorials

XX. Return to I.

West Virginia Division of Environmental Protection
Office of Abandoned Mine Lands & Reclamation
Stream Restoration Group's

HOLISITIC WATERSHED APPROACH PROTOCOL

I. Define the *study area*.

- Select mainstem stream and determine watershed boundary.

II. Establish *comprehensive monitoring network* within the *study area*.

- Select stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations and at extensive locations throughout the mainstem tributary stream reach.

III. Obtain coordinates and map *comprehensive monitoring network* for Geographical Information System (GIS) input.

- Collect sampling station positions.
- Generate project map of all sampling stations.

IV. Implement sampling sweeps of the *comprehensive monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity, and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
    - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November.
- Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
- Perform fish survey at selective stream sampling stations only.

V. Review all data collected. (If watershed is large continue. If watershed is small skip to VIII.)

- Analyze changes in tributary and mainstem stream segments and compare tributaries.

VI. Establish *streamlined monitoring network* within the *comprehensive monitoring network*.

- Select stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations only.

VII. Implement sampling sweeps of *streamlined monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
    - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.

VIII. Review all data collected.

- Analyze changes in tributary and mainstem stream segments and compare tributaries.
- Prioritize mainstem tributaries according to degree of impairment.

IX. Define *focus study area*.

- Select impaired tributary within *comprehensive monitoring network* and determine watershed boundary.

X. Establish *focus area monitoring network* within the *focus study area*.

- Locate polluted coal mine drainage source sampling stations within impaired tributary watershed.
- Select stream sampling stations throughout impaired tributary watershed.

- Select impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage influx.
- Select receiving stream sampling stations upstream and downstream of the confluence with the impaired tributary.

XI. Obtain coordinates and map *focus area monitoring network* for Geographical Information System (GIS) input.

- Collect sampling station positions.
- Generate project map of all sampling stations.

XII. Implement sampling sweeps of *focus area monitoring network*.

- Conduct *Water Quality Study* sweeps six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect pollution source water sample at origin.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
        - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
- Perform field measurements.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at source sampling stations.
    - Obtain stream flow.
    - Obtain source flow.

- Conduct *Biological and Physical Study* one time between April and November.
- Perform stream habitat assessment and qualitative benthic macroinvertebrate survey upstream and downstream of polluted coal mine drainage project areas.

XIII. Review data.

- Analyze *focus area monitoring* network data.

XIV. Report findings.

- Prepare *Water Quality Study* report of findings and suggestions.
- Determine extent of impairment polluted coal mine drainage contributes to the *focus area* tributary.
- Determine site specific polluted coal mine drainage remediation technology for the sources at each project area.
    - Evaluate chemical suitability of selected polluted coal mine drainage remediation technology.
        - Reference variables include alkalinity, acidity, dissolved oxygen, total iron, ferrous and ferric iron, and aluminum.
    - Evaluate physical suitability of selected polluted coal mine drainage remediation technology.
        - Reference variables include flow and geography.
- Determine instream polluted coal mine drainage remediation technology for stream benefits in addition to, or in lieu of site specific polluted coal mine drainage remediation.
    - Reference variables include acidity and flow.

XV. Establish *post construction focus area monitoring network* when polluted coal mine drainage remediation is complete in the *focus study area*. (If initial *study area* contains other impaired tributaries which have not been addressed, repeat IX through XIV.)

- Locate constructed polluted coal mine drainage remediation systems within polluted coal mine drainage remediation projects.
- Select stream sampling stations throughout *focus study area*.
- Select the previously impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage remediation project influx.
- Select receiving stream sampling stations upstream and downstream of the confluence with the previously impaired tributary.

XVI. Obtain coordinates and map *post construction focus area monitoring network* for Geographical Information System (GIS) input.

- Collect positions for any sampling stations added since pre-design *focus area monitoring network* was established.
- Generate project map of all sampling stations.

XVII. Implement sampling sweeps of *post construction focus area monitoring network*.

- Conduct *Water Quality Study* sweeps six times per year during the initial first year period; four times during the second year period; and two times per year during the third and every subsequent year period spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect untreated source water sample at origin if possible.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
        - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
    - Collect treated source water sample at polluted coal mine drainage remediation system outflow.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
        - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
- Perform field measurements.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at untreated source sampling stations.
    - Measure temperature, pH, specific conductivity, Oxygen Reduction Potential, and dissolved oxygen at treated source sampling stations.
    - Obtain stream flow.
    - Obtain treated source flow at polluted coal mine drainage remediation system outflow.

- Conduct *Biological and Physical Study* one time between April and November, at least one year after completion of project construction.
- Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of polluted coal mine drainage remediation project influx.

XVIII. Implement sampling sweeps of the *comprehensive monitoring network* when polluted coal mine drainage remediation is complete throughout initial *study area*. (Repeat IV.)

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
    - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November.
- Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
- Perform fish survey at selective stream sampling stations only.

XIX. Review data.

- Analyze changes in stream water quality.
- Analyze effectiveness and efficiency of constructed polluted coal mine drainage remediation systems.

XX. Report findings.

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- Prepare *post construction Water Quality Study* report.
- Determine the effect of constructed polluted coal mine drainage remediation systems on the polluted coal mine drainage sources, *focus area monitoring networks*, and *comprehensive monitoring network.*

XXI. Return to I.